JICABLE '03

A.6.3.

Microvaristor based field grading elements for HV terminations

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Abstract: A new silicone field grading material is presented, which is based on microvaristor particles as active fillers in a silicone matrix. It shows a very nonlinear resistivity, extending over a large range of current density, and the field strength can be precisely adjusted to specific needs. The nonlinear electrical resistivity can be designed tailor-made by the processing conditions of the microvaristors and the filler content. The electrical properties of these materials and first experimental results with a HV cable termination are discussed. Computer simulations of the electrical field distribution at voltage impulses show good agreement with the experimental observations. These simulations, combined with the adjustable characteristics of the field grading material, will allow to optimise both, the geometrical design and the electrical properties of cable accessories.

Keywords: field grading, microvaristors, computer simulations, HV terminations

Résumé: Un nouveau matériau pour le contrôle du champ électrique est présenté. Ce matériau, dont la résistance est fortement non-linéaire, est composé d'une matrice polymère et de particules microvaristors. La non-linéarité peut être ajustée en modifiant les paramètres de fabrication des microvaristors et leur concentration. Les propriétés électriques de ce matériau sont présentées et les premiers résultats expérimentaux d'une extrémité de câble haute tension sont discutés. Les simulations numériques de la répartition du champ électrique pour des impulsions de tension correspondent bien aux observations expérimentales et permettent donc d'optimiser aussi bien la géométrie que les propriétés électriques des accessoires pour câbles.

Mots clés: contrôle du champ électrique, microvaristor, simulations numériques, extrémité de câble haute tension

1. Introduction

Electrical field control with nonlinear resistive materials is standard in MV cable accessories. The advantages of this concept of field grading are thin and compact design, installer friendly products and cost effective production, as e.g. extrusion of field grading sleeves. However most of these field grading materials are carbon black and/or SiC filled polymers. A disadvantage of the carbon black filled materials is the difficulty of controlled manufacturing compounds with well reproducible electrical properties. The reason for the scattering in the electrical properties in these materials is the fact that one has to chose the filler content of the carbon black close to the percolation threshold. This means that the electrical properties are very sensitive to small variations in the processing conditions and the particle morphology. These disadvantages can be overcome by choosing microvaristor particles as fillers in the polymer matrix. Here - in contrast to carbon black and/or SiC filled materials - the nonlinear electrical properties are not determined by the dispersion of the particles and poorly controlled particle-particle interface properties, but by the nonlinear resistivity of the microvaristors itself. This nonlinear behaviour of the microvaristors can be designed tailor-made to special electrical requirements by the formulation of the different metal oxides and the parameters of the sintering process, analogous to the well established manufacturing of ZnO-based surge arresters. The intrinsic, nonlinear electrical properties of the filler particles thus offer a new, additional degree of freedom in the design of field grading materials for cable accessories. In this paper the material properties of the microvaristors and the field grading compound are discussed. In addition first experimental results with this new field grading material on HV cables will be reported. The experimental results show good agreement with the computer simulations performed for voltage impulses. These computer simulations, together with the possibility to adjust the nonlinear electrical properties of the field grading material by using microvaristors, allow to optimise both, the geometrical design and the electrical properties of HV terminations This will enable the use of the well established concept of field grading by nonlinear